U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

REPRINT INCORPORATES CHANGE 1

Subject: PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS

Date: 5/23/85

Initiated by: AAS-200

AC No: 150/5345-28D

Change:

1. PURPOSE. This advisory circular (AC) contains the Federal Aviation Administration (FAA) standards for Precision Approach Path Indicator (PAPI) systems which provide pilots with visual glideslope guidance during approach for landing.

2. CANCELLATION. Advisory Circular (AC) 150/5345-28C, Specification for L-851 Visual Approach Slope Indicators, dated March 23, 1977, and AC 150/5340-25, Visual Approach Slope Indicator (VASI) Systems, dated September 24, 1976, are cancelled.

3. APPLICATION. The standards contained herein are recommended by the FAA in all applications involving airport development of this nature. The standards are an acceptable means for compliance with Federal Aviation Regulation (FAR) Part 152 for projects funded under the Airport Improvement Program or with FAR Part 139 where such facilities may be required. Where alternate means are proposed, it must be demonstrated that equivalent levels of performance, safety, and for federally funded projects, equivalent cost effectiveness, are achieved.

4. METRIC UNITS. To promote an orderly transition to metric units, this advisory circular includes both English and metric dimensions. The metric conversions may not be exact equivalents and, until there is an offical changeover to the metric system, the English dimensions will govern.

Leonard E. Mudd

LEONARD E. MUDD
Director, Office of Airport Standards

FEDERAL AVIATION ADMINISTRATION

STANDARDS FOR

PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS

CHAPTER 1 - EQUIPMENT SPECIFICATIONS

1. GENERAL. This chapter contains the equipment specification for precision approach path indicator (PAPI) systems.

2. CLASSIFICATION.

a. Type.

(1) L-880 - System consisting of 4 light units.

(2) L-881 - System consisting of 2 light units.

b. Style.

(1) Style A - Voltage powered (multiple circuit) systems.

(2) Style B - Current powered (series circuit) systems.

c. Class.

(1) Class I - Systems which operate down to -35° C.

(2) Class II - Systems which operate down to -55° C.

d. Options.

(1) Lamp bypass devices as specified in paragraph 6g.

(2) An isolation transformer consolidating harness for Style B systems as specified in paragrapn 6f.

3. APPLICABLE DOCUMENTS. The following documents, of the issue in effect on the date of application for qualification, form part of this specification and are applicable to the extent specified herein.

a. FAA Advisory Circulars.

AC 150/5345-1	Approved Airport Lighting Equipment
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors

AC 150/5345-47	Isolation Transformers for Airport Lighting Systems
AC 150/5345-49	Specification L-854, Radio Control Equipment

b. FAA Standards and Drawings.

FAA-STD-020	Transient Protection, Grounding, Bonding, and Shielding
Drawing C-6046	Frangible Coupling, Type 1 and 1A, Details

c. Military Specifications and Standards.

MIL-C-7989	Covers, Light Transmitting, for Aeronautical Lights, General Specification for
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-462	Electromagnetic Test Methods

d. Illuminating Engineering Society (IES) Transaction.

LM-35	IES Approved Method for Photometric Testing of Floodlights Using Incandescent or Discharge Lamps

(FAA advisory circulars may be obtained from the Department of Transportation, Subsequent Distribution Unit, M-494.3, Washington, D.C. 20590.)

(FAA standards, specifications, and drawings may be obtained from the Federal Aviation Administration, Program Engineering and Maintenance Service, Washington, D.C. 20591.)

(Military publications may be obtained from the Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120, Attention: Code CDS.)

(IES publications may be obtained from the Illuminating Engineering Society, 345 E. 47th Street, New York, NY 10017.)

4. SYSTEM DESCRIPTION. The PAPI system consists of the following components:

a. Four identical light units (Type L-880) or two identical light units (Type L-881).

b. A power and control unit (PCU) (for style A systems only).

c. Aiming and calibration equipment (may be integral to the light units).

5. ENVIRONMENTAL REQUIREMENTS. The equipment shall be designed for outdoor installation and continuous operation under the following environmental conditions:

a. Temperature. Any temperature from -35° C (Class I systems) or -55° C (Class II systems) +55° C.

b. Humidity. Any relative humidity up to 100 percent.

c. Sand and Dust. Exposure to windborne sand and dust particles.

d. Wind-blown Rain. Exposure to wind-blown rain from any direction.

e. Wind. Exposure to wind speeds up to 100 mph (161 km/hr) from any direction.

f. Salt Spray. Exposure to a salt-laden atmosphere.

g. Sunshine. Exposure to solar radiation.

6. LIGHT UNITS.

a. Photometric Requirements. Each light unit shall have at least two lamps and shall provide a beam of light split horizontally to produce white light in the top sector and red light in the bottom sector. When viewed by an observer at a distance of 1000 feet (300 m), the transition from red light to white light shall occur within an angle of 3 minutes of arc at the beam center and within an angle of 5 minutes of arc at the beam edges. A line drawn through the center of the transition band at +10°, 0°, and -10° shall be straight to within 3 minutes of arc. Figure 1 shows the light distribution and intensity in candellas required of each light unit. The light colors shall be aviation white and aviation red as defined in MIL-C-25050. Light transmitting covers shall conform to the requirements of MIL-C-7989. The lamps shall have a minimum rated life of 1000 hours in this application, and shall achieve full intensity within 5 seconds after a cold start.

b. Light Unit Construction. Each light unit shall be designed so that dynamic loading due to wind, or static loading due to snow, will not cause the light pattern to be displaced. The weight of each light unit shall not exceed 100 pounds (45 kg) (unless the PCU is incorporated in the light unit) and shall be no higher than 40 inches (1 m) when installed at the minimum mounting height. The light unit shall have an overhang or other means to inhibit rain or snow from reaching the optical lens.

c. Mounting Provisions. The light units shall have a minimum of three mounting legs which shall be adjustable to permit leveling where one side of the unit is installed up to 1 inch (25 mm) higher or lower than the opposite side. The legs shall consist of mounting and adjusting hardware, 2-inch electrical metallic tubing (EMT) (furnished by the installer), frangible couplings conforming to FAA drawing C-6046, and flanges suitable for mounting on a concrete pad. The adjusting hardware shall be designed to prevent any displacement of the optical system due to vibration. Alternate mounting systems may be proposed where equivalent rigidity, frangibility, and adjustability are provided.

d. Aiming. The light units shall be provided with integral adjustments to permit accurate vertical positioning of the center of the light beam at any elevation between 2 and 8 degrees. The center of the light beam is defined as the transition band between red and white light. An aiming device shall be provided that will

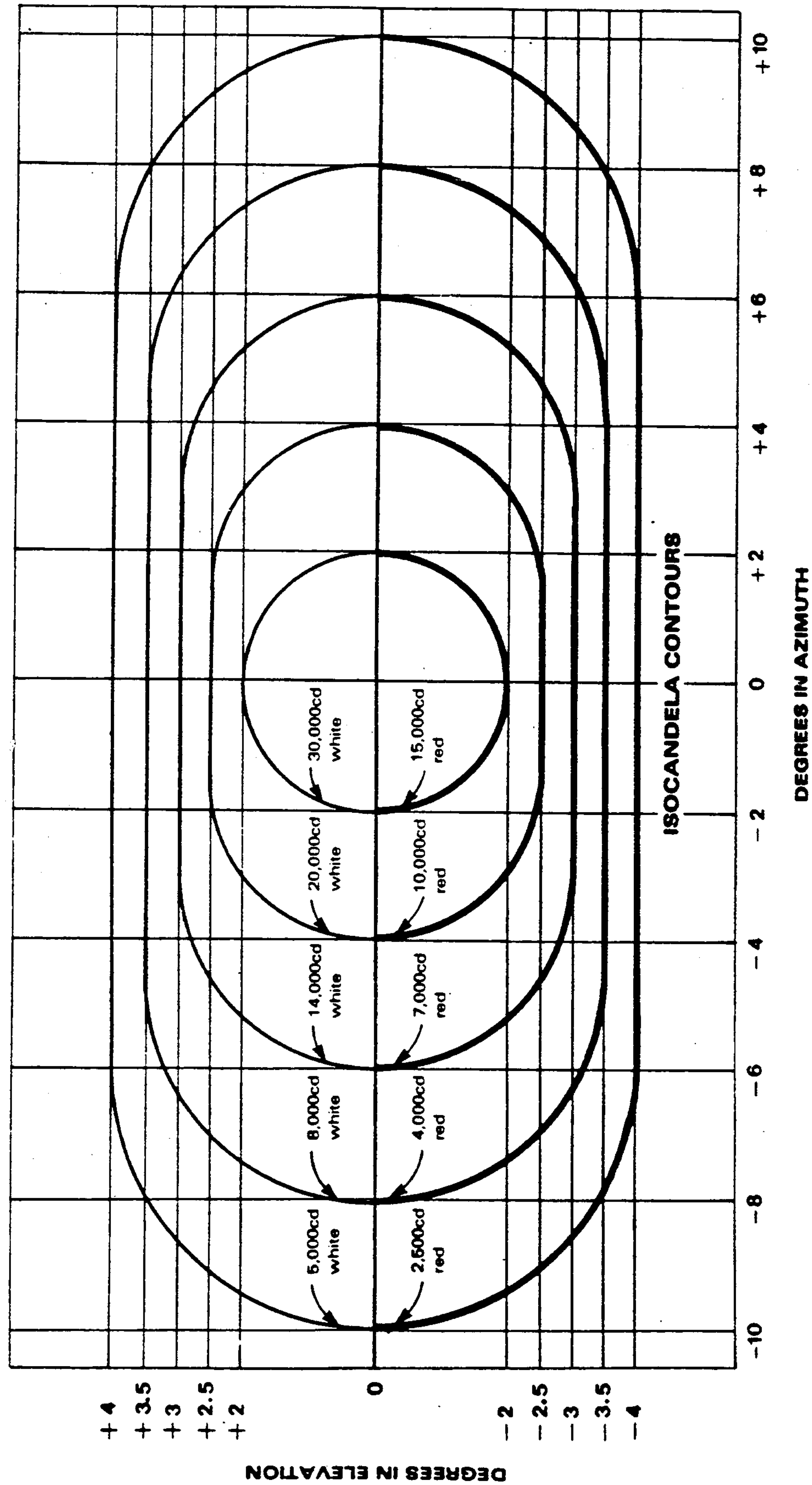


Figure 1. Light intensity requirements for PAPI

indicate the vertical angle of the light beam center within an accuracy of ±3 minutes of arc. The aiming device shall indicate minutes of arc, and shall have at least 1 division every 10 minutes. Alternatively, the units may be factory calibrated to a fixed vertical angle (to an angle specified by the purchaser) where means are provided to permit field installation at the desired angle within an accuracy of ± 3 minutes. The manufacturer shall provide a procedure to check the calibration of the aiming system in the field.

e. Tilt Switch. A tilt switch system shall be provided which deenergizes all the lamps in the system when the optical pattern of one light unit is inadvertently lowered between 1/4 and 1/2 degree or raised between 1/2 and 1 degree with respect to the preset aiming angle. The tilt switch shall have a time delay of 10-30 seconds that will prevent intermittent tilt switch activation due to vibration. The tilt switch shall have fail-safe operation so that any malfunction of the tilt switch, including loss of input power, shall deenergize the PAPI system.

f. Leads. All wiring shall be introduced into the light units through leads fitted with factory molded plugs. The length of the leads shall be adequate to extend from the unit through a flexible conduit to a frangible coupling at ground level. Strain relief shall be provided to prevent pulling on the lead from being transmitted to its connections in the light unit. Style B systems shall have Class A, Style 1 or 6 plugs (specified in AC 150/5345-26), or equivalent, to mate with the output lead of the isolation transformer. Alternately, a harness may be provided for use in the transformer housing which will accept the output of several transformers and combine them into a single receptacle which is placed just below the frangible point. This receptacle is then mated with a plug from the light unit. Style A systems may use any plug with adequate capacity and electrical performance equivalent to that of an L-823 plug.

g. Shorting Device. A lamp bypass device, which provides a short circuit around a burned-out lamp, shall be offered as an option.

7. POWER SUPPLY AND SYSTEM CONTROL.

a. Style A Systems. The circuitry required to perform the functions described in this paragraph may be enclosed in a separate power and control unit (PCU) or may be incorporated in one of the light boxes. If incorporated in a light box, the weight of the combined unit shall not exceed 150 pounds (68 kg).

(1) Voltage Regulation. The PAPI system may be designed to operate from any standard utility single-phase alternating-current service voltage less than 600 volts. A circuit breaker shall be provided to permit deenergizing the input power for field maintenance. The system shall be adjustable so that lamp socket voltage may be held within 3 percent of its design value on the brightest step when the following conditions occur: (1) the input voltage deviates up to 10 percent above or below its nominal value, (2) the individual light units are spaced between 10 (3 m) and 30 feet (10 m) apart, and (3) the power supply is located from 0 to 100 feet (30 m) from the nearest light unit.

(2) System Control. A photoelectric control shall be provided to switch the system to full intensity for day and reduced intensity at night. The day mode shall be activated when the illumination on the photocell rises to 50-60 footcandles, and the night mode shall be activated when the illumination drops to 25-35 footcandles. A time delay of 45-75 seconds shall be incorporated to prevent

switching due to stray light or temporary shadows. In case of failure of the photoelectric control circuitry, the system shall revert to low intensity. Two night intensity settings, approximately 5 percent and 20 percent of full intensity, shall be provided to allow the user to select either of the settings to accommodate local site conditions of extraneous lighting. A contactor or other means shall be provided to allow the system to be turned on and off from a remote location, or by means of a radio controller (specified in AC 150/5345-49). When the system is initially energized and the photocell detects daylight conditions, the low intensity step shall be selected for 2 to 3 seconds before switching to the high intensity step.

(3) Transient Suppression. For solid state equipment, transient suppression shall be provided in accordance with FAA-STD-020, paragraph 3. The transient suppression devices shall be capable of withstanding lightning transient consisting of a 10 x 20 microsecond current surge of 15,000 amperes with the subsequent power-follow current and a voltage surge of 10 kV/microsecond. The system shall also withstand without damage the repeated application of an overvoltage transient on the input power lines equal to 500 volts peak for a duration of 50 milliseconds.

(4) Lamp Protection. Failure of one or more lamps shall not cause any overvoltage or transients which will result in damage to the remaining lamps.

b. Style B Systems. These systems operate directly from a series lighting circuit having a current range of 2.8 to 6.6 amperes. Lamps used shall be compatible with one of the isolation transformer sizes as specified in AC 150/5345-47. Components of the series lighting circuit will be supplied by others.

8. GROUNDING. Exposed noncurrent-carrying metal parts shall be grounded. Grounding shall be continuous to at least one mounting flange as described in 6c.

9. EQUIPMENT FINISH. The exterior of all units shall be either a bright orange or yellow to maximize the conspicuity of the equipment.

10. MATERIALS. All parts and materials shall be suitable for the intended purpose and shall be adequately protected against corrosion. The components shall have adequate capacity and shall not be operated in excess of the component manufacturer's recommended rating. Any plastic components exposed to sunlight shall be made of U.V. stabilized material. All fasteners shall be of corrosion resistant material. Ferrous metals shall be galvanized or given other equal corrosion protection. Copper bearing hardware in contact with aluminum shall be plated with cadmium, nickel, or zinc.

11. MAINTENANCE. All system components shall be designed for ease of maintenance and shall have a mean-time-between-failures of at least six months (excluding lamps.) If required, means shall be provided for refocusing the system after relamping. The design of the system shall be such that adjustment and repairs can be made with commercially available tools. Special tools, if required for servicing, shall be furnished by the manufacturer.

12. WORKMANSHIP. The equipment shall be fabricated in accordance with the highest quality workmanship. All wiring shall be neatly run and laced. All sharp edges and burrs shall be removed. Painted surfaces shall be free from runs, blotches, and scratches.

13. INSTRUCTION BOOK. An instruction book containing the following information shall be furnished with each system.

a. Complete system schematic and wiring diagrams showing all components cross-indexed to the parts list.

b. Complete parts list with applicable rating and characteristics of each part and with the component manufacturer's name and part number.

c. Installation instructions, including aiming, calibration of the aiming system, focusing, and adjustment of the tilt switch.

d. Maintenance instructions, including relamping procedure, theory of operation and trouble-shooting charts.

e. Operating instructions.

14. QUALIFICATION REQUIREMENTS. Procedures for obtaining qualification approval are contained in AC 150/5345-1, Approved Airport Lighting Equipment. The following tests are required to demonstrate compliance with the specification. The tests may be run on the power supply and a single light unit, with the other units simulated by a resistive load.

a. Visual Examination. The equipment will be examined for compliance with the requirements on size, weight, materials, finish, and quality of workmanship.

b. High Temperature Test. A high temperature test shall be conducted in accordance with MIL-STD-810, method 501.2, Procedure II. The equipment shall be subjected to a stable temperature of +55° C (±5° C) for a period of 4 hours after temperature stabilization. The system shall be operated throughout the test. Any deterioration in materials or performance will be cause for test failure.

c. Low Temperature Test. A low temperature test shall be conducted in accordance with MIL-STD-810, Method 502.2, Procedure II. The system shall be exposed to a minimum of -35° C (for Class I systems) or -55° C (for Class II systems) for 24 hours. The equipment shall be operated at the beginning and end of the test. Any deterioration in materials or performance will be cause for test failure.

d. Rain Test. A wind-blown rain test shall be conducted in accordance with MIL-STD-810, Method 506.2, Procedure I. The rain shall be at a rate of 5.2 inches/hour (130 mm/hour) with an exposure time of 30 minutes per side. The system shall be operated throughout the test. Any deterioration of system performance or excessive accumulation of water in equipment cabinets shall be cause for test failure.

e. Salt-Fog Test. A salt-fog test shall be conducted in acordance with MIL-STD-810, Method 509.2, Procedure I. The test duration shall be 48 hours exposure and 48 hours drying. Any evidence of damage, rust, pitting, or corrosion (except to sacrificial coatings) shall be cause for test failure.

f. Wind Loading. The manufacturer shall demonstrate by wind tunnel tests or static loading that the system will withstand the specified wind load from any direction in azimuth without displacing the optical pattern more than allowed in the rigidity test (subparagraph k).

g. Frangibility Test. The manufacturer shall demonstrate that the frangibility of the mounting legs is equivalent to that of a 2-inch frangible coupling depicted in FAA drawing C-6046.

h. Transient Suppression Test. For Style A systems with solid-state components, the power input lines shall be tested for resistance to the lightning transient in accordance with method CS06 of MIL-STD-462, including Notices 1, 2, and 3. All Style A systems shall be tested for resistance to the overvoltage transient given in paragraph 7a(3). After the transients have been applied to the system, it shall continue to supply specified voltage to the lamp sockets.

i. Photometric Tests. The manufacturer shall conduct a photometric test to prove conformance with the color, intensity, and beam pattern requirements of paragraph 5. All lamps used for photometric testing shall be randomly selected from a production lot (if available). A complete set of photometrics shall be run on one set of lamps. Intensity along the horizontal and vertical axes shall be checked for two additional sets of lamps to demonstrate repeatability. If refocusing is required after lamp replacement, it shall be done according to the recommended procedure to demonstrate that the required photometrics are produced. Before testing, the test equipment shall be calibrated in accordance with IES Transaction LM-35. The measurements must be taken at a distance sufficient to allow full focusing of the beam.

j. Lens Certification. The manufacturer shall provide a certification from the lens manufacturer that the lenses meet the requirements of MIL-C-7989 and the color requirements of MIL-C-25050.

k. Rigidity Test. A uniformly distributed load (sand or other suitable material) of 15 psf (73 kg/m^2) shall be applied over the entire top surface of the light unit. Before applying the load, the unit shall be set up and the light pattern displayed on a vertical surface 20 feet (6 m) from the front of the unit. The top, bottom, and the sides of the beam pattern and any other characteristic features shall be marked on the wall. A framework or other method may be used to ensure that the sand used to load the system does not spill over the sides. The load shall then be applied by letting the sand pour down on the center of the light unit. After loading the unit with the required amount of material, the beam pattern shall be checked for displacement from the markings, and the load shall be left in place for 5 hours. Upon removal of the load, the beam pattern shall again be checked against the original markings. Under all conditions, the beam pattern shall remain within $\pm 1/4$ inch (6 mm) of the original markings.

l. <u>Aiming Device Test</u>. The manufacturer shall conduct a test of the aiming device, using a procedure approved by the FAA, to demonstrate that, when the light unit is moved via the adjustment mechanism, the measuring device registers the change within the allowable tolerance. The measuring device shall be checked at one degree intervals throughout the system's adjustment range.

m. <u>Operational Test</u>. The manufacturer shall conduct an operational test, using a test procedure approved by the FAA, to demonstrate compliance with all operating requirements. The procedure shall test the tilt switch, the power supply performance, photoelectric controller, and any other operational features. The system shall be operated with one lamp out per light unit to demonstrate that the proper voltage is still applied at the sockets of the operational lamps. The manufacturer shall demonstrate that failure of a lamp will not produce transients large enough to damage the remaining lamps.

15. <u>PRODUCTION TESTS</u>. The manufacturer shall submit for FAA approval a test procedure to verify the light output and aiming device accuracy for each production unit. After FAA approval, these tests shall be used on all production units. The visual examination in subparagraph 14a and the operational test in subparagraph 14m shall also be performed on each production system.

CHAPTER 2 - SITING AND INSTALLATION STANDARDS

16. SIGNAL PRESENTATION. The precision approach path indicator (PAPI) is a system of either four or two identical light units placed on the left of the runway in a line perpendicular to the centerline. The boxes are positioned and aimed to produce the signal presentation described below.

a. Type L-880 System. When making an approach, the pilot will:

(1) When on or close to the established approach path, see the two units nearest the runway as red and the two units farthest from the runway as white; and

(2) When above the approach path, see the unit nearest the runway as red and the three units farthest from the runway as white; and when further above the approach path see all the units as white; and

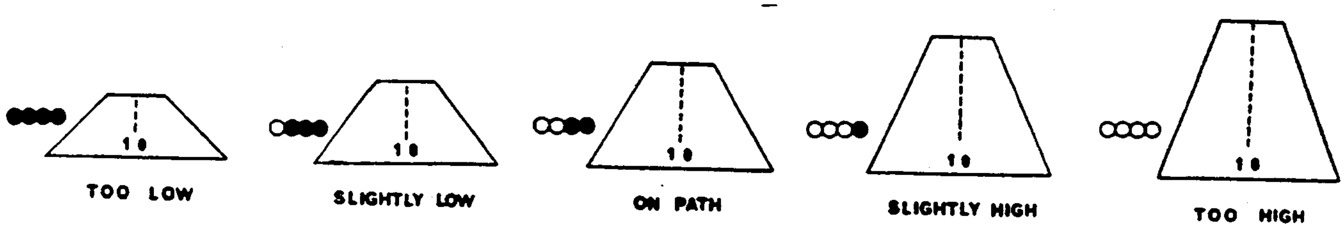
(3) When below the approach path, see the three units nearest the runway as red and the unit farthest from the runway as white; and when further below the approach path see all units as red.

b. Type L-881 System. When making an approach, the pilot will:

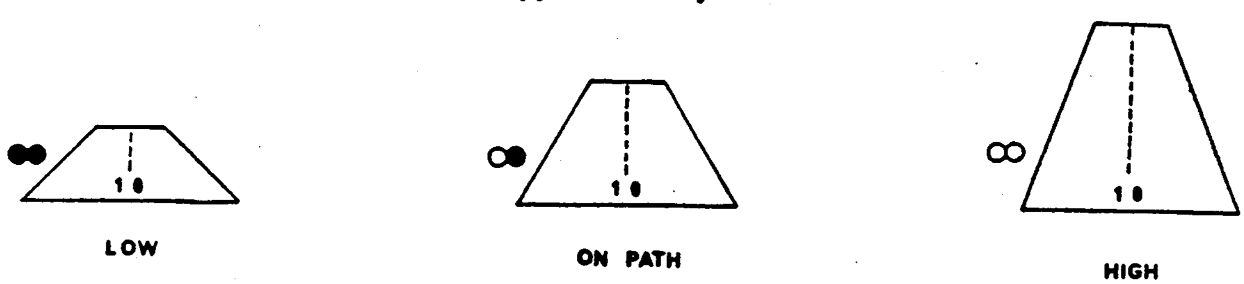
(1) When on or close to the established approach path, see the unit nearest the runway as red and the other unit as white; and

(2) When above the approach path, see both units as white; and

(3) When below the approach path, see both units as red.



a. Type L-880 system



b. Type L-881 system

Figure 1. PAPI Signal Presentation

17. GENERAL SITING CONSIDERATIONS. When viewed from the approach end, the PAPI system shall be located on the left side of the runway. In the event of siting problems, such as conflicts with runways or taxiways, the PAPI may be located on the right side of the runway. The PAPI must be sited and aimed so that it defines an approach path with adequate clearance over obstacles and a minimum threshold crossing height. If the runway has an Instrument Landing System (ILS) glide slope already established, the PAPI is installed as described in paragraph 18 so that the visual glide slope will coincide (as much as possible) with the electronic one produced by the ILS. If there is no ILS on the runway, the PAPI glide slope is chosen as described in paragraph 19. Aiming of the light units is described in paragraph 20. Other siting tolerances and considerations which are common to all PAPI installations are described in paragraph 21.

18. SITING PAPI ON A RUNWAY WITH AN ILS GLIDE SLOPE. When siting PAPI on a runway with an established ILS glide slope, the PAPI visual approach path should coincide, as much as possible, with the one produced electronically by the ILS. To accomplish this, the PAPI is placed at the same distance from the threshold as the virtual source of the ILS glide slope within a tolerance of ±30 feet (±10 m). The PAPI is aimed at the same angle as the ILS glide slope. This procedure must be modified for runways that serve aircraft in height group 4 (see table 1) due to the distance between the pilot's eye and the ILS antenna. For these locations, the distance of the PAPI from the threshold shall equal the distance to the ILS glide slope source plus an additional 300 feet +50, -0 (90 m +15,-0).

19. SITING PAPI ON A RUNWAY WITHOUT AN ILS GLIDE SLOPE. When an ILS glide slope is not present, the designer must determine a position and aiming for the PAPI which will produce the required threshold crossing height and clearance over obstacles in the approach area.

a. Threshold Crossing Height (TCH). The TCH is the height of the lowest on-course signal at a point directly above the intersection of the runway centerline and the threshold. The minimum allowable TCH varies according to the height group of aircraft that uses the runway, and is shown in table 1. The PAPI approach path must provide the proper TCH for the most demanding height group that uses the runway.

b. Glide Path Angle. The visual glide path angle is the center of the on-course zone, and is normally 3 degrees when measured from the horizontal. For non-jet runways, this may be raised to 4 degrees if required to provide obstacle clearance. If used, the higher angle must be specified in a Notice to Airmen (NOTAM) and published in the Airport Facility Directory (see paragraph 24).

c. The PAPI Obstacle Clearance Surface. The PAPI obstacle clearance surface is established to provide the pilot with a minimum clearance over obstacles during approach. The PAPI must be positioned and aimed so that no obstacles penetrate this surface. The surface begins 300 feet (90 m) in front of the PAPI system (closer to the threshold) and proceeds outward into the approach zone at an angle 1 degree less than the aiming angle of the third light unit from the runway (for an L-880), or the outside light unit (for an L-881). For an L-880 with a 3° glide path and 20 minutes separation between light units, the third light unit from the runway would be aimed at 2° 50' elevation. The surface extends 10 degrees on either side of the runway centerline extended, and extends 4 statute miles from its point of origin. The

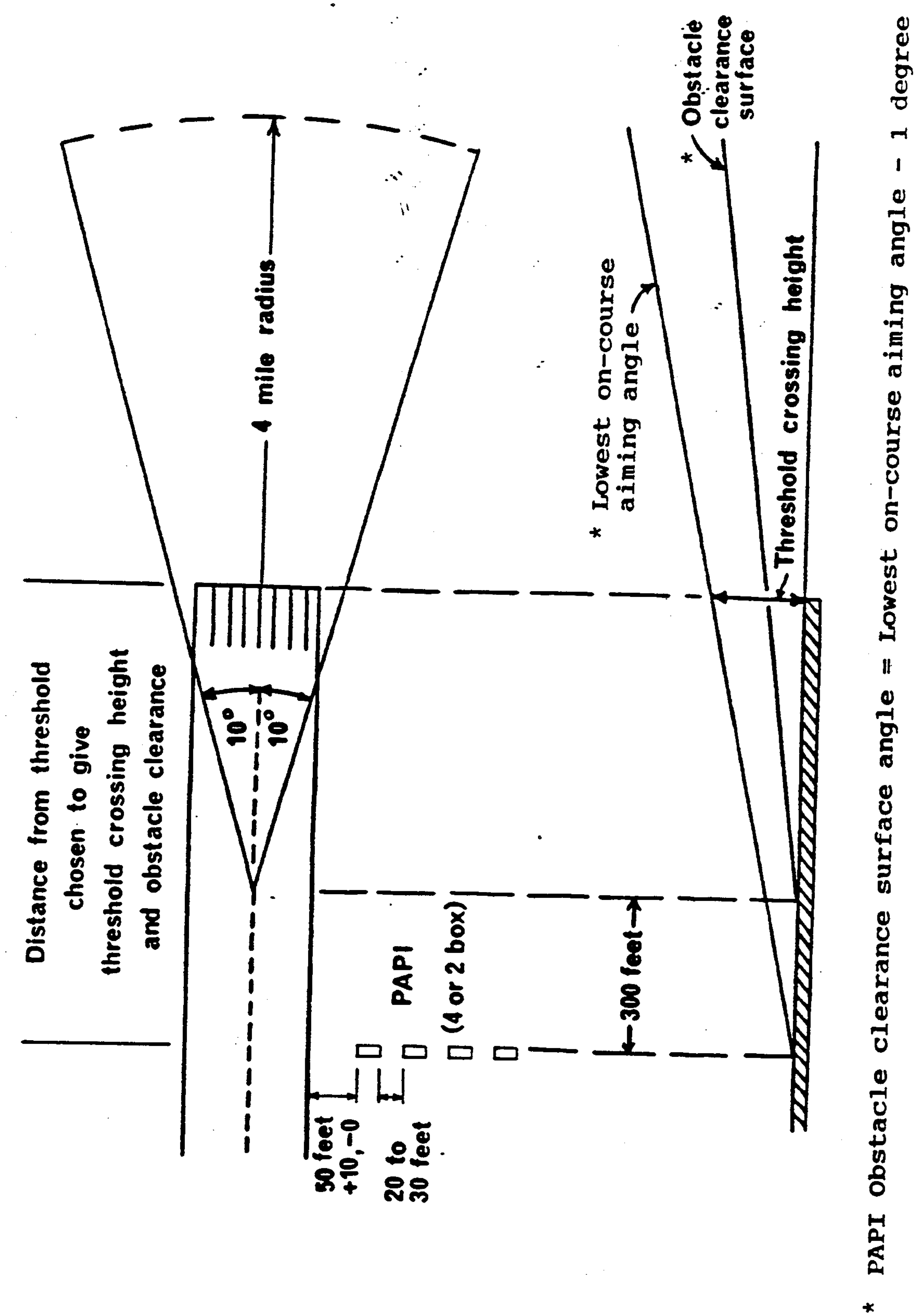


Figure 3. PAPI Obstacle Clearance Surface

surface is shown graphically in figure 3. If a site survey determines that there is an obstacle which penetrates the obstacle clearance surface, and cannot be removed, then the glidepath angle must be changed or the PAPI system moved further from the threshold. By moving or reaiming the PAPI, the designer must reposition the PAPI obstacle clearance surface so it will not be penetrated by an obstacle.

Table 1. Visual threshold crossing heights

Representative aircraft type	Approximate cockpit-to-wheel height	Visual threshold crossing height	Remarks
Height group 1 General aviation Small commuters Corporate turbojets	10 feet or less	40 feet +5, -20 10 meters +2, -6	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
Height group 2 F-28, CV-340/440/580 B-737, DC-9, DC-8	15 feet	45 feet +5, -20 12 meters +2, -6	Regional airport with limited air carrier service
Height group 3 B-727/707/720/757	20 feet	50 feet +5, -15 15 meters +2, -6	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 feet.
Height group 4 B-747/767, L-1011, DC-10, A-300	Over 25 feet	75 feet +5, -15 22 meters +2, -4	Most primary runways at major airports.

20. AIMING. After the visual glide path angle has been selected, the PAPI units are aimed to define that path. The standard aiming angles for Type L-880 and Type L-881 systems are shown in tables 2 and 3.

Table 2. Aiming of Type L-880 (4-box) PAPI relative to a preselected glide path.

Light Unit	Aiming Angle (in minutes of arc)	
	Standard installation	Ht group 4 aircraft on runway with ILS
Unit nearest runway	30' above glide path	35' above glide path
Next adjacent unit	10' above glide path	15' above glide path
Next adjacent unit	10' below glide path	15' below glide path
Next adjacent unit	30' below glide path	35' below glide path

Table 3. Aiming of Type L-881 (2-box) PAPI relative to a preselected glide path

Light Unit	Aiming angle (in minutes of arc)
Unit nearest runway	15' above glide path
Unit farthest from runway	15' below glide path

21. OTHER SITING DIMENSIONS AND TOLERANCES.

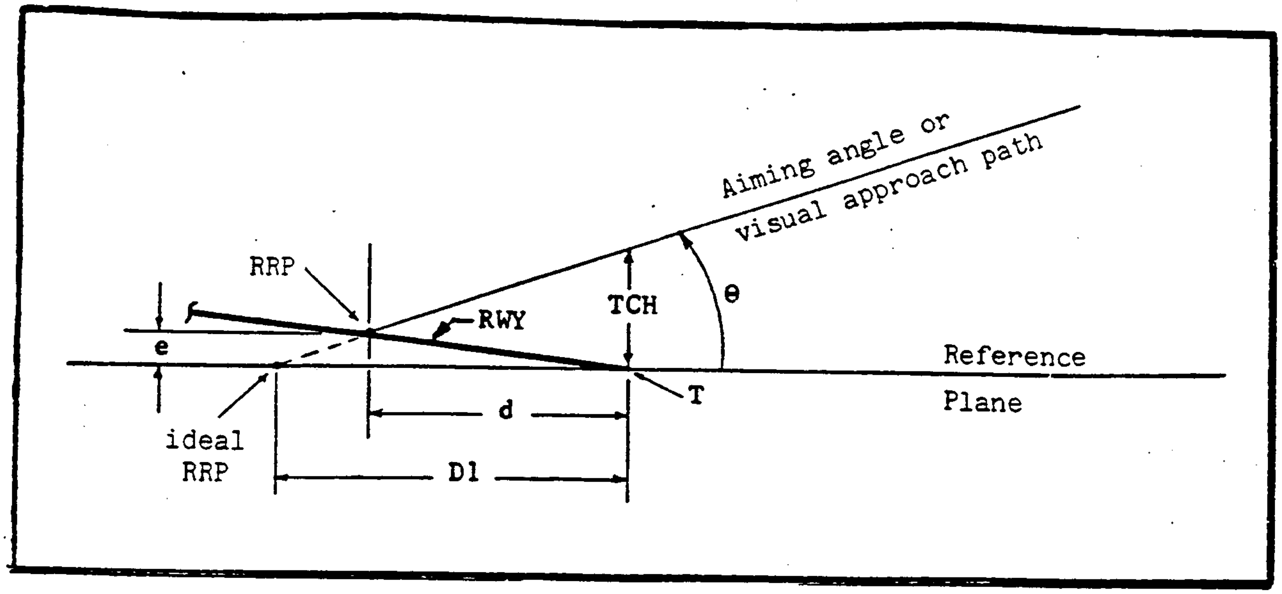
a. Distance from Runway Edge. The inboard light unit shall be no closer than 50 feet, +10, -0 (15 m, +3, -0) from the runway edge or to other runways or taxiways. This distance may be reduced to 30 feet (10 m) for small general aviation runways used by nonjet aircraft.

b. Separation Between Light Units. The PAPI units shall have a lateral separation of between 20 and 30 feet (6 to 9 m) for an L-880 system, and 10 to 20 feet (3 to 6 m) for an L-881 system. The larger separation is recommended for the L-881 because it increases the usable range of the system. For the L-880, the distance between boxes shall not vary by more than 1 foot (0.3 m).

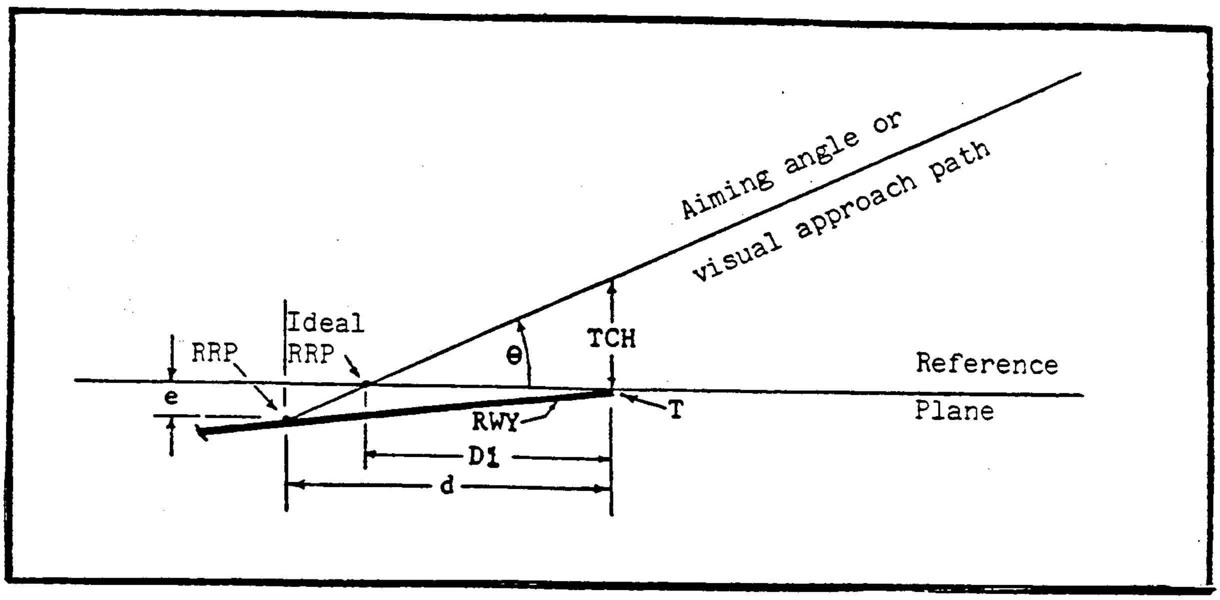
c. Azimuthal Aiming. Each light unit shall be aimed outward into the approach zone on a line parallel to the runway centerline within a tolerance of ±1/2 degree.

d. Mounting Height Tolerances. The beam centers of all light units shall be within ±1 inch of a horizontal plane. This horizontal plane shall be within ±1 foot (0.3 m) of the elevation of the runway centerline at the intercept point of the visual glidepath with the runway (except for the condition in subparagraph g below).

e. Tolerance Along Line Perpendicular to Runway. The front face of each light unit in a bar shall be located on a line perpendicular to the runway centerline within ±6 inches.



a. Siting station displaced toward threshold.



b. Siting station displaced from threshold.

Symbols
D1 = ideal (zero gradient) distance from threshold
RWY = runway longitudinal gradient
TCH = threshold crossing height
T = threshold
e = elevation difference between threshold and RRP
RRP = runway reference point (where aiming angle or visual approach path intersects runway profile)
d = adjusted distance from threshold
θ = aiming angle

Figure 4. Correction for runway longitudinal gradient

f. Correction for Runway Longitudinal Gradient. On runways where there is a difference in elevation between the runway threshold and the runway elevation at the PAPI, the location of the light units may need to be adjusted with respect to the threshold in order to meet the required obstacle clearance and TCH. Where such a condition exists, the following steps (shown in figure 4) are taken to compute the change in the distance from the threshold required to preserve the proper geometry.

(1) Obtain the runway longitudinal gradient. This can be done by survey or obtained from "as-built" drawings or airport obstruction charts.

(2) Determine the ideal (zero gradient) distance from the threshold in accordance with the instructions above.

(3) Assume a level reference plane at the runway threshold elevation. Plot the location determined in (2) above.

(4) Plot the runway longitudinal gradient (RWY).

(5) Project the visual glide path angle to its intersection with the runway longitudinal gradient (RWY). Then solve for the adjusted distance from threshold (dimension d on figure 4) either mathematically or graphically.

(6) Double-check to see that the calculated location gives the desired threshold crossing height.

g. Other Siting Considerations.

(1) Where the terrain drops off rapidly near the approach threshold and severe turbulence is experienced, the PAPI should be located farther from the threshold to keep the aircraft at the maximum possible threshold crossing height.

(2) On short runways, the PAPI should be as near the threshold as possible to provide the maximum amount of runway for braking after landing.

(3) At locations where snow is likely to obscure the light beams, the light units may be installed so the top of the unit is a maximum of 6 feet (2 m) above ground level. This may require locating the light units farther from the runway edge to ensure adequate clearance for the most critical aircraft. Since raising the light units also raises the threshold crossing height for the visual glide path, the lights may also have to be relocated closer to the threshold to remain within specified tolerances.

22. POWER AND CONTROL DESIGN.

a. Feeder Circuit. The PAPI may be specified to operate from a standard utility voltage (Style A) or from a constant current power supply (Style B). The cable for the feeder circuit should be FAA Type L-824 (specified in AC 150/5345-7, Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits, current edition) or equivalent, rated for 600 volts, and sized to deliver the rated voltage and current. Lightning arresters for power and control lines should be provided as required (the output lines for the L-828 regulator used for Style B systems have integral lightning protection). Fuses and circuit breakers should be in accordance with the equipment ratings.

(1) Style A Systems.

(i) Input Voltage. PAPI systems may be designed to operate from any standard utility voltage at the manufacturer's choice. The designer should attempt to obtain a PAPI which will operate from the service voltage available, to avoid a separate transformer to derive the operating voltage required by the PAPI. The designer should determine whether there is a substantial variation in the utility line voltage throughout the course of the day or week. If there is, some sort of voltage regulation should be provided to ensure that the PAPI provides specified brightness without shortening lamp life due to overvoltage. The cable used to distribute power to the individual light units should be sized so that the voltage drop does not exceed the compensation capabilities built into the PAPI.

(ii) Location of the Power and Control Unit (PCU). The PCU is the assembly which receives the input power. Depending on the PAPI design, it may be a relatively heavy device, and should therefore be located as far from the runway as possible to present the minimum possible obstruction to aircraft. If the PCU is incorporated in one of the light boxes, that box should be the one placed farthest from the runway. If the PCU is a separate unit, it should be mounted at the minimum possible height, and either located outside the runway safety area (if possible), or frangibly mounted. The runway safety area is defined in AC 150/5300-4, Utility Airports - Air Access to National Transportation, or AC 150/5300-12, Airport Design Standards - Transport Airports (current editions).

(2) Style B Systems. PAPI systems which operate from a constant current source must interact with several pieces of FAA-specified equipment. The power source is an L-828 constant current regulator (specified in AC 150/5345-10) with an output current of 6.6 amps. The regulator will automatically compensate for a ± 10 percent deviation from nominal voltage, and may be ordered with three or five brightness steps. The five-step regulator is recommended, since tests have shown that the lowest brightness step on a three-step regulator may still be too bright for rural applications. The output circuit of the regulator excites the primary circuit of several L-830 transformers (specified in AC 150/5345-47), sized to handle the load provided by the PAPI lamps.

b. Wiring the Light Boxes. For Style A systems, the cable used to deliver the power to the individual boxes must be large enough to minimize voltage drop. All PAPI light boxes have a tilt switch, and provision for grounding. All wiring which enters the PAPI box must be through plugs and receptacles which will separate if the box is struck by an aircraft. The receptacles are located and held at the frangible point on the breakable couplings. A length of flexible watertight conduit conveys the wire between the breakable coupling and the PAPI box. The flexible conduit is required so that the PAPI box may be aimed. All underground connections should be made with either splices or plugs and receptacles intended for that purpose.

c. Brightness Control.

(1) Voltage Systems. The Style A system is equipped with a photocell for automatic control of brightness, which will choose between a day and night intensity setting. There are two night intensity settings, and the PAPI may be configured to deliver either intensity when the night mode is selected.

(2) Style B Systems. The brightness of the Style B system is controlled by the L-828 regulator which energizes the circuit. It is recommended that the PAPI not be powered from an edge light circuit, since this means that the edge lights must be left on at full intensity during the day. Rather, the PAPI should be powered by a dedicated regulator, with the brightness controlled manually or by a photocell. The photocell is configured to reduce the regulator brightness setting to a lower value when the ambient lighting decreases to 25-35 footcandles. The photoelectric control shall switch the regulator back to full intensity when the ambient lighting reaches 50-60 footcandles. The photoelectric control shall have a time delay of at least 30 seconds to prevent false switching due to stray light or temporary shadows.

d. Manual Control. The PAPI may be turned on and off by a number of different methods. For Style A systems, a contactor is provided in the PCU to allow the system to be turned on and off via control level signals. For Style B systems, the PAPI is turned on and off by the regulator control circuitry. The remote control which activates these systems may be located in the control tower, flight service station, or other attended facility. Alternatively, the control lines may be activated by the output of an L-854 radio control receiver (specified in AC 150/5345-49). The L-854 allows the PAPI to be turned on by a pilot on approach, or by a ground control station.

e. Other Control Configurations.

(1) PAPIs On Both Runway Ends. It is desirable to be able to control PAPIs independently for each runway end. Energy may be conserved by turning on only the PAPI which serves the active runway end, and turning off both systems when the runway is inactive.

(2) Interlock Relay. During hours of darkness, it is desirable that the PAPI be on only when the runway lights are on. To provide this feature, an interlock relay can be installed in series with the night intensity contacts on the photocell controller. The contacts are normally open but are closed, by photocell action, during hours of darkness. The normally open contacts of the interlock relay are closed only when the relay senses current in the runway circuit. This configuration prevents energizing the PAPI during hours of darkness unless the runway lights are on. It will not affect daytime operation of the PAPI.

(3) Lamp Bypass. Lamp bypass devices, which are an optional feature, are recommended for those Style B PAPIs that are powered by resonant-type constant current regulators. These regulators will increase the output current as the number of isolation transformers with open secondaries (caused by burned-out lamps) increases. The increase in current will cause more lamp failures, which will in turn further increase the current. This situation is particularly critical when the connected load is small compared to the regulator rating (less than 50 percent). The lamp bypass device will prevent this effect by shorting the secondary of the isolating transformer.

23. INSTALLATION DETAILS.

a. Foundations. Foundations for mounting light boxes shall be made of concrete, and designed to prevent frost heave or other displacement. The foundation should extend at least 12 inches (0.3 m) below the frost line. A column may be provided under each mounting leg for attachment of the mounting flanges, or a pad with appropriate reinforcing may be used. The pad or surface stabilization should extend at least 1 foot (0.3 m) beyond the light boxes to minimize damage from mowers, and should not be more than 1 inch (25 mm) above grade. All light boxes shall be frangibly mounted to the foundation. For Style B systems, a transformer housing may be installed in the pad below grade to provide a convenient protected location for the isolation transformer. The transformer housing also provides a good place for the splices or plugs used in the Style A system.

b. Extraneous Lighting. Since the effectiveness of the PAPI system is dependent upon seeing a definite red and/or white signal from the light units only, care should be taken to assure that no other lights are located close enough to the system to interfere with the signal presentation to the pilot.

c. Electrical. The installation should conform to the applicable sections of the National Electrical Code and local codes. All electrical connections to the light unit shall be made via plugs and receptacles to allow the unit to pull free in the event it is struck by an aircraft. Any extra control circuitry should be housed in an enclosure to protect it from the environment. All underground cable should be installed in accordance with item L-108 of AC 150/5370-10, Standards for Specifying Construction of Airports, current edition. Any underground connections should be made via splices or appropriately rated plugs.

24. COMMISSIONING NOTICE TO AIRMEN (NOTAM). The Flight Service Station (FSS) which has jurisdiction over the airport where the PAPI is installed should be notified when the system is ready to be commissioned. The FSS should be requested to issue a commissioning NOTAM, and to forward copies of this NOTAM to the National Flight Data Center (ATO-250), the local Air Traffic Control Tower, the Air Route Traffic Control Center, and the FAA Regional Office. This will ensure that the new PAPI system will be included in the Airport Facility Directory. The following items should be reported to the FSS.

a. Airport name and location.

b. Runway number and location of PAPI (left or right side of runway).

c. Type of PAPI (4 box or 2 box).

d. Glide slope angle.

e. Threshold crossing height.

f. Date of commissioning.